

Instruction Manual

Type 825 Mass Flow Controller

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SECTION I

GENERAL DESCRIPTION

1.1 Purpose of Equipment:

The 825 Mass Flow Controller is a combination flow transducer and flow control for gases which will:

- (1) Measure the mass flow rate of a gas flowing through its housing,
- (2) Provide a 0 to 5 VDC or 0 to 10 VDC output which is proportional to mass flow, and
- (3) Control the gas flow (to a remotely set level) with an internal servo amplifier and internal proportional control valve.

A ± 15 VDC power supply is required, as well as a DC voltage reference level for flow control input. Gas flow is sensed by the transfer of heat to the flowing stream from a section of tubing, called the sensor tube, which is heated above the ambient. (See theory of operation, to follow.) Another flow path, which is in parallel with the sensor tube, contains one of many combinations of laminar flow restrictors, and sets the transducer flow range. The lowest and highest full scale ranges available are 5 scc/m and 20 sl/m.

All metal parts in contact with the gas stream are 316 stainless steel; seals can be Viton or Kalrez. The 825 must be inserted in the gas stream and is provided with the following tube fittings: Swagelok (Crawford Fitting Co.), VCR and VCO (Cajon Co.). The inlet is equipped with a filter to trap particles of 20 microns.

1.2 Purpose of Instruction Manual:

This manual describes the basic operation of the Datametrics model 825 Mass Flow Controller, and contains information and instructions to assist the user in the installation and maintenance of this instrument. Documentation is also included to assist in major repairs, modifications, and system interfacing.

This manual covers the 825 Mass Flow Controller only. Auxiliary equipment which may be used with the 825 is listed in this manual, but detailed information about that equipment is contained in the appropriate equipment manual.

1.3 Equipment Supplied:

- (1) Model 825 Mass Flow Controller
Weight: 18 ounces
Overall Dimensions (HWL): 4.4" x 1.0" x 5.1"
- (2) Nuts and ferrules when ordered with Swagelok fittings
- (3) Instruction Manual

1.4 Auxiliary Equipment:

The following list describes Datametrics auxiliary equipment for the type 825 Mass Flow Controller:

- (1) Type 1600 Digital Flow Display and Controller with Option 38 will control a single 825 and provide power, digital readout, flow reference level, and valve control.
- (2) Type 1605 Controller for Automatic Mass Flow Controller is available in two-channel or five-channel versions for simultaneous operation of 825 Mass Flow Controllers.
- (3) Cable 718-15 will connect type 825 to type 1600 with option 38.
- (4) Cable 797-15 will connect type 825 to type 1605, one required for each channel.
- (5) Mating Connector (P/N 105064-00) is for the user who wishes to fabricate a custom cable to connect to his own control system.
- (6) Mating Fitting Kit 4DM contains a pair of glands and nuts for adapting 1/4" OD tubing to Cajon VCR.
- (7) Mating Fitting Kit 4FM contains a pair of glands and nuts for adapting 1/4" OD tubing to Cajon VCO.
- (8) Sensor (P/N 603784-00) is available to replace sensors which may become clogged or corroded in severe applications. (Use P/N 606582-00 for fast response sensors.)

- (9) Bypass Kit (P/N 105676) is available for users who make non-standard bypasses.

If not using the type 1600 or 1605 controllers, the following is required:

- (1) A ± 15 VDC power supply (See specifications, Section 1.5)
- (2) A voltage readout device of either 5 VDC or 10 VDC full scale
- (3) A variable voltage source for setting the flow reference level
- (4) A switch closure circuit for manually commanding the valve

1.5 Specifications

Specifications, Type 825 Mass Flow Controller

Ranges: 0 to

SCC/M:	5, 10, 20, 50, 200, 500
SL/M:	1, 2, 5, 10, 20

Linearity: $\pm 1\%$ of Full Scale

Calibration Accuracy with N₂ 1% of Full Scale
(Same as pure air):

Resolution: 0.1% of Full Scale

Other Gases: By correction factor or
special calibration

Response: (for final control values greater than 20% FS)	Standard	Fast Response
To 63% of Final Value:	1.5 sec	250 msec
To 98% of Final Value:	5 sec	1 sec

Line Pressure: 80 Torr absolute to 500 psig

Sensor Differential pressure 0 to 5 Torr
at 14.7 psia, full scale flow

A Orifice: - 3 psid
B Orifice: - 6
C Orifice: - 20
D Thru J: - 100

<0.01%/Psi

<0.05% of Full Scale/
degrees C

<0.1% of Reading/degrees C

5 or 10 VDC Full scale into
2,000 ohm or larger load
resistance

<0.1 ohm

Same range as transducer
output from a 50 ohm or less
source

5-15 VDC or Float=Automatic
V=Valve Closed

1 to 100% of Full Scale

5 to 40 degrees C

Datametrics P/N 105064-00
(AMP Part Nos. 1 ea. 583764-1
and 2 ea. 4-40 x 1/2" mtg.
screws

316 SS with Viton seals
Optional seals include Kalrez

1/4" Swagelok

1/4" VCR, 1/4" VCO

Standard

1.6 Identification of Controls:

There are four controls on the 825 circuit board. Only one of these, the zero adjustment potentiometer, can be routinely used during normal operations; the others are used for recalibration or after repair/replacement of components. Recalibration and repair are covered in Section 5 of this manual. Location of these controls are shown in the circuit board assembly drawing at the end of this manual.

ZERO ADJUST: R17 is used to zero adjust the instrument under a no-flow condition; it is accessible through a hole in the cover.

GAIN: R26 adjusts the gain of the output stage. Its range of operation is $\pm 10\%$. Larger changes in gain are effected by changing resistor R34. This control, and the ones that follow, are accessible after removing the instrument cover.

LINEARITY: R4 affects transducer sensitivity as well as linearity. It is used to set the bridge voltage for the flow sensor circuit.

FOLDOVER: R22 sets the point at which the foldover prevention circuit becomes operative.

SECTION II

INSTALLATION AND ADJUSTMENT

2.1 Installation:

| WARNING |

When installed for use with hazardous gases, the user must check the installation against leaks.

| WARNING |

Locate the 825 Mass Flow Controller in an area which will not be subjected to large changes in temperature. Avoid mounting in cabinets next to equipment which runs unusually hot or cold. This will minimize zero drift. (See specifications for temperature coefficient.)

There are two drilled and tapped (8-32) mounting holes on the bottom of the instrument. These are especially useful when mounting a group of instruments in a system. A single 825 may be supported by the plumbing, being careful to avoid vibration or resonance of the line containing the 825. Vibrations which feed through to the valve armature will cause oscillations in the gas flow which may not show up in the flow output reading, but may be evident elsewhere in the system, such as fast-response pressure transducers located downstream of the 825.

The flow stream which is to receive the 825 Mass Flow Controller should be a single gas or mixture of gases free of particulate contamination and supplied at a regulated pressure. Altering the gas species will not upset the control function, but the flow reading will no longer be in calibration. A 20 micron particle filter is in the 825 inlet fitting and prevents clogging of the small passageways in the sensor and bypass. This filter itself will become clogged if subjected to high flow rates of gases with particulate contamination. A clean gas stream is essential, and with new plumbing, flush the lines first with a clean gas to blow out particles trapped during assembly.

Arrange the plumbing so that it can be spread apart for easy insertion/removal of the Mass Flow Controller, especially when equipped with Swagelok fittings. Use two wrenches to tighten the tube fitting, one on the fitting nut and one on the 7/8 hex of the male connector. Do not remove either male connector from the instrument during installation/removal. When using Swagelok fittings (Crawford Fitting Co, Solon, Ohio) in cramped quarters,

it may be convenient to pre-swage the nut and ferrules onto the tubing with a pre-swaging tool (or an extra fitting). Follow the directions for swaging and retightening in the Swagelok catalog.

In some applications it may be desirable to install a separate shut-off valve in series with (downstream) the 825 Mass Flow Controller. The reason for this is a general characteristic of proportional control solenoid valves (such as in the 825 Mass Flow Controller); they do not have high seating force. To insure positive closure after a period of wear and accumulated deposits, a shut-off valve such as the Nupro "BK" series should be used. This precaution will not be necessary when benign gases are used and the system is clean.

After plumbing is completed, plug in the electrical connector and secure it with the two clamping screws on the connector.

2.2 Adjustment:

With the 825 powered, adjust the zero reading with the potentiometer which is accessible through the hole in the cover. Turn the potentiometer with a small screwdriver until a zero voltage is measured at either of the following places: (1) between pin 3 (output) and common (pins 2, B, C, 10) at the transducer, or (2) at the controller input (signal + and signal - on the 1600 back panel). When using a 1600 or 1605 controller, it would be convenient to zero the controller first (front panel zero adjustment screw) with the 825 disconnected from the back panel. Then the 825 can be connected, allowed to warm up, and zero adjusted using the 1600 or 1605 readout. After adjusting zero at the 825, minor zero shifts can be adjusted from the front panel of the 1600 or 1605. When adjusting zero, insure that the flow is stopped by closing the 825 valve with the switch on the front panel of the 1605 or 1600/Option 38 or by grounding pin L. Additionally, close other valves which are near the 825 or reduce the system pressure (or differential pressure) to zero.

When using several 825's to blend gases into a manifold, adjust the upstream pressures to be approximately equal. This will prevent backflow into any of the lines should the manifold pressure be raised to one of the supply pressures by opening the 825 valve with the front panel switch on the 1605 or 1600/Option 38. This is a case where an additional shutoff valve located downstream of each 825 (See Section 2.1) will add to system versatility and reliability.

2.3 General:

| CAUTION |

A few precautions should be borne in mind when installing or removing the 825, and during operation.

Do not unscrew the fittings from the 825 body during installation or removal. This is a maintenance operation which should only be performed by trained personnel after the 825 has been removed to a clean area equipped for instrument maintenance.

Use the two-wrench technique for tightening tube fittings as described in Section 2.1. Do not apply a wrench to the 1" square body of the 825. Do not brace against the 825's cover while using the wrenches.

Do not exceed the pressure rating (see specifications) during use. Forward differential pressure, with the valve closed, increases the seating force and tends to insure a good seal. Conversely, reverse differential pressure may unseat a closed 825 valve, resulting in backflow through the instrument. (Backflow can be read as a negative output.) In systems where a back differential pressure occurs as a normal part of system operation, it may be necessary to install a shut-off valve (see Section 2.1) downstream of each 825.

SECTION III

OPERATING INSTRUCTIONS

3.1 General Operating Procedure:

Turn on the power at the controller (1605, 1600/Option 38, or system supply) and wait 15 minutes for complete warm-up. Check the zero flow reading. Adjust if necessary as described in Section 2.2. Small fluctuations in the zero reading can be adjusted from the front panel of the 1605 or 1600/Option 38. Next, apply upstream gas pressure and check that the 825 valve opens and closes under control of the front panel switch on the 1605 or 1600/Option 38. With this switch in the "AUTO" position, the flow should be controlled to the set point level; see the 1605 or 1600 manual for instructions on reading and changing the control set point level. Change the set point level and observe that the flow rate follows the change in set point.

Turn off the gas flow by placing the front panel switch on the 1605 or 1600/Option 38 into the "CLOSE" position. In user-designed systems the same function can be accomplished by grounding "L" of the circuit board edge connector. These procedures close the 825 valve but keep the flow transducer section warmed up and ready for the next flow command. Turning the power off (or a power failure) also closes the 825 valve.

3.2 Special Operating Procedures:

3.2.1 Changing gas type:

Table 1 in this manual contains gas factors for a wide variety of gases and vapors. These gas factors, F , can be used to obtain the gas flow when an 825 is used for a gas other than the one for which it was calibrated. If the unit is calibrated for gas A, but is used with gas B, then the instrument reading should be multiplied by F_B/F_A , the ratio of gas factors. For a mixture of gases (which do not react with each other) an effective gas factor, F_M , can be calculated from the individual gas factors, F_A and F_B , by the following formula:

$$\frac{1}{FM} = \frac{.01A}{FA} + \frac{.01B}{FB}$$

where A = volume % of gas A
B = volume % of gas B

For any gas not on the list in Table 1, a gas factor can be calculated from the following formula:

$$FX = \frac{Cpm (AIR)}{Cpm (gas x)}$$

where Cpm (AIR) = molar specific heat of air
Cpm (gas x) = molar specific heat of the gas

3.2.2 Ratio control:

A system for controlling the ratio of two gases can be made using an 825 and another Mass Flow Transducer, such as an 831 or even another 825. The other Mass Flow Transducer should be in the major gas stream. Its output (which should be in the zero to 5 volts DC or 10 volts DC range) is then divided by a potentiometer to the desired level and applied to the reference input, pin A, of the 825. The 825, which should be in the minority gas stream, will then control its gas stream to always be a fixed proportion of the main flow.

3.2.3 Conditioned input:

The 825 circuit board is equipped with solder switches which can be used to interrupt the internal feedback loop (transducer section output to error amplifier input) and connect the error amplifier input to pin J. The transducer output, pin 3, can then be conditioned in any manner desired by the system designer, and then fed back to the 825 via pin J.

To implement this option, open solder switch SS12 and close solder switch SS13. These switches are labeled on the circuit board and also are shown on the circuit board assembly drawing in this manual.

3.2.4 Pressure control:

When the conditioned input option is implemented by opening and closing the solder switches, as described in Section 3.2.3, above, the 825 is essentially divided into two independent systems. The first system is the flow transducer, consisting of the sensor, bypass, bridge amplifier, and output amplifier. The

second system is the control system, consisting of the servo error amplifier, valve drive circuit, and proportional solenoid valve. The only link between these two systems is that they are both in the same flow stream.

The control system can be fed a pressure signal, from a pressure transducer with an output range of 5 or 10 volts DC, on pin J of the circuit board edge connector. A pressure reference voltage can be applied to pin A. If the 825 is located upstream of the chamber containing the pressure transducer, and the chamber is being continuously pumped or purged, this arrangement will result in the chamber pressure being controlled by the 825. At the same time, the 825 will be indicating the flow necessary to maintain system pressure.

3.3 General Operating techniques:

The following suggestions and cautions should help the operator and/or system designer attain optimum system performance and avoid certain system pitfalls.

3.3.1 Foldover:

The thermal type of flowsensor (see Theory of Operation, Section IV) used in the 825 has the following general output characteristic: Initially, output increases linearly with flow. At higher flows, the output begins to flatten out and reaches a peak. At still higher flows the output begins to decrease and asymptotically approaches zero.

In the 825, the foldover in the sensor output that occurs at high flow is eliminated with an auxilliary circuit. This circuit is adjusted at the factory with potentiometer R22.

3.3.2 Differential pressure:

In some system designs, the differential pressure across the flow control valve is much higher when that valve is closed than when flow is being controlled. This is due to other instruments and devices in the flow stream which restrict flow and have their own differential pressure requirements. An 825 with a large orifice may not be able to open against this maximum differential pressure, even though control of flow is no problem. (This is a common problem for low-power proportional solenoid valves.) The maximum differential pressure for each orifice is shown in the table below. The orifice letter code is part of the model number appearing on each 825 (after the first dash).

<u>Orifice</u>	<u>Maximum dp</u>
A	10 psid
B	20
C	40
D and smaller	over 100 psid

3.3.3 Control delay:

When the status of the 825 is changed from closed to flow control (by disconnecting pin "L" from ground while maintaining a reference voltage on pin "A"), there will be a delay before flow control is established. This delay is about 5 seconds (see specifications) for a standard 825, and is shortest when the 825 is controlling near full scale. An 825 with the fastest response option has a delay of about 1/4 second. Therefore, choose the lowest range 825 which will cover all the system requirements.

Some operations require a high purge flow for a few seconds before establishing flow control at a much lower flow. In this case choose the 825 for the low flow application and use a separately controlled flow stream for purging the system.

3.3.4 Low pressure operation:

At low absolute pressures (about 80 Torr absolute for the flow channel sizes in the 825) there is a transition region between laminar flow and free molecular flow where the calibration of the 825 is not valid. In this flow regime the partitioning of flow between the sensor tube and the bypass is no longer independent of flow or pressure. The 825 will continue to indicate and control flow, but will not be in calibration.

The onset of this transition flow regime is a function of the mean free path of the gas and the hydraulic radius of the smallest flow channel. For room temperature air flowing through the 825, the calibration should begin to stray at pressures below 80 torr absolute.

SECTION IV

THEORY OF OPERATION

4.1 Detailed Description:

There are four principles of operation which make up the 825 flow measurement and control system. They are:

- thermal sensing of mass flow
- laminar partitioning of flow
- closed-loop servo operation
- proportional control of integrated valve

Combined, these principles become a system which can (1) sense mass flow directly and with a linear response, (2) measure flows over a wide range of full scale capacities, and (3) accurately control flow with no field adjustments.

Thermal sensing of mass flow by exchanging small quantities of heat with the gas stream is a well established technique. The capacity of a gas stream to convey heat is proportional to the product of mass flow and specific heat. Since the specific heat of gases varies only slightly with temperature and pressure, heat transfer techniques of flow measurement will respond directly to mass flow.

In the 825, the flow sensor is a 316SS tube several inches long with a very small inside diameter. The center of this tube is wound with two adjacent coils (single layer) of stainless steel electrical wire. These coils serve two purposes: (1) they uniformly heat the central section of tubing, and (2) they act as resistance thermometers which sense the temperature difference between the upstream and downstream coils.

The coils are connected in series and powered as part of a bridge circuit balanced at zero flow. When gas flows through the tube, the upstream coil is cooled more than the downstream coil, and the bridge circuit becomes imbalanced.

This imbalance is amplified and calibrated to provide a voltage output proportional to mass flow.

By itself, the flow sensor described above can measure flow in the range of zero to five scc/m. Higher flow ranges are accommodated by partitioning the flow so that a constant fraction of the flow bypasses the flow sensor in a parallel flow path.

The bypass flow is controlled with a flow restrictor (called a "bypass") which consists of many small flow channels in parallel.

Each channel has a high ratio of length to hydraulic diameter. The flow in these channels is well within the laminar flow regime (as is the flow in the sensor tube), ensuring that the ratio of bypass flow to sensor flow is constant for all flow rates in the range of the transducer.

A major goal in the design of the bypass was that each flow channel have an accurately controlled geometry. This accuracy provides consistent and predictable flow properties and allows the bypass to be disassembled and reassembled or replaced without affecting calibration. Bypass accuracy is achieved by electro-chemically etching the flow channels completely through stainless steel discs of accurate thickness. Each channel consists of two sections, etched into separate but adjacent discs. An outer channel extends from the outer diameter halfway inward to the inner diameter of the first disc. An inner channel extends from the halfway point inward to the inside diameter of the second disc.

When these two discs are placed together and aligned, the inner and outer channels overlap at the halfway point, forming a continuous flow path. Each such pair of discs is separated by a solid disc forming the wall of the flow channels.

This combination of discs is repeated until the desired flow properties are attained. The stack of discs is held together with alignment pins and end caps, forming a bypass which is easily inserted into the body of the controller through the threaded hole used for the inlet fitting.

The 825 contains a control circuit consisting of an error amplifier used in a servo control loop to regulate the flow through the valve.

The servo action adjusts the valve opening so that the analog voltage of the flow is equal to the set point voltage. Phase lag compensation is included in the circuit for stable operation over the full range of flow.

The type 825 Flow Controller contains a proportional control valve integrated into the body of the transducer. A high-efficiency magnetic circuit actuates the armature, which contains the valve seat. The armature is totally encapsulated in 316SS; there is no compromise between corrosion-resistance and magnetic properties. Two flat springs of 316SS support the armature so that it moves without friction. This results in a very smooth low hysteresis flow/voltage relationship. Nine orifice sizes allow control of low throughout all the transducer ranges.

The valve can be disassembled easily by removing the outlet fitting. Also, the closing force preload on the orifice can be adjusted with the valve assembled by inserting a screwdriver in the end of the outlet fitting.

The valve is located very close to the flow sensor, and its internal volume has been kept to a minimum. This permits best operation of the flow control loop, and "tuning" of the servo amplifier is unnecessary.

4.2 Referenced Literature

- (1) Van Atta - Vacuum Science and Engineering
For a discussion of gas flow and the transition flow regime.
- (2) Patent applied for on the bypass construction will be referenced here when granted.
- (3) Patent applied for on the fast response sensor will be referenced here when granted.

TABLE 1
GAS FACTORS

<u>CHEMICAL NAME</u>	<u>SYNONYM</u>	<u>FORMULA</u>	<u>F</u>
Acetylene	Ethyne	C ₂ H ₂	.66
Air			1.00
Allene	Propadiene	C ₃ H ₃	.47
Ammonia		NH ₃	.77
Argon		Ar	1.40
Arsine		AsH ₃	.76
Boron Trichloride	Boron Chloride	BCl ₃	.39
Boron Trifluoride	Boron Fluoride	BF ₃	.58
Bromine		Br	.88
1,3 Butadiene	Biethylene,	C ₄ H ₆	.38
	Erythrene, Vinylethylene		
Butane		C ₄ H ₁₀	.29
Butene	Alpha-Butylene	C ₄ H ₈	.33
Carbon Dioxide		CO ₂	.74
Carbon Monoxide		CO	1.00
Carbon Tetrachloride		CCl ₄	.35
Carbonyl Fluoride		COF ₂	.62
Carbonyl Sulfide	Carbon Oxysulfide	COS	.68
Chlorine		Cl ₂	.84
Chlorine Trifluoride		ClF ₃	.46
Chloroform	Trichloromethane	CHCl ₃	2.02

<u>CHEMICAL NAME</u>	<u>SYNONYM</u>	<u>FORMULA</u>	<u>F</u>
Cyanogen	Dicyan,	C2N2	.50
	Oxalonitrile		
Cyclopropane	Trimethylene	C3H6	.52
Deuterium		D2 or 2H2	1.00
Diborane		B2H6	.50
Dichlorosilane		SiH2Cl2	.47
Dichloro Methyl Silane		SiHCl2CH3	.27
1,1 Difluoroethylene	Genetron 1132A	H2C:CF4	.48
Dimethylamine		(CH3)2NH	.42
Dimethyl Ether	Methyl Ether	(CH3)2O	.44
Ethane		C2H6	.55
Ethyl Chloride	Chlorethane	C2H5Cl	.41
Ethylene	Ethene	C2H4	.67
Ethylene Oxide	Epoxyethane	C2H4O	.61
Fluorine		F2	.93
Fluoroform	Freon 23,	CHF3	.57
	Trifluoromethane		
Freon 11	Trichlorofluoromethane	CCl3F	.35
Freon 12	Dichlorodifluoromethane	CCl2F2	.36
Freon 13	Chlorotrifluoromethane	CClF3	.42
Freon 1381			.40
Freon 14		CF4	.48
Freon 22	Chlorodifluoromethane	CHClF2	.43
Freon 114	Dichlorotetrafluorethane	C2Cl2F4	.22

<u>CHEMICAL NAME</u>	<u>SYNONYM</u>	<u>FORMULA</u>	<u>F</u>
Methyl Fluoride	Fluoromethane	CH ₃ F	.75
Methyl Mercaptan	Methanethiol	CH ₃ SH	.58
Methyl Trichlorosilane		SiCl ₃ CH ₃	.25
Neon		Ne	1.39
Nitric Oxide		NO	.99
Nitrogen		N ₂	1.00
Nitrogen Dioxide		NO ₂ or N ₂ O ₄	.44
Nitrogen Trioxide		N ₂ O ₃	-
Nitrogen Trifluoride		NF ₃	.55
Nitrous Oxide		N ₂ O	.75
Oxygen		O ₂	.99
Pentaborane	Boronhydride	B ₅ H ₉	.18
n Pentane		C ₅ H ₁₂	.22
Phosgene	Carbonyl Chloride	COCl ₂	.50
Phosohine		PH ₃	.79
Propane		C ₃ H ₈	.32
Propylene	Propene	C ₃ H ₆	.45
Silane		SiH ₄	.68
Silicon Tetrachloride		SiCl ₄	.33
Silicon Tetrafluoride		SiF ₄	.39
Sulfur Dioxide		SO ₂	.71
Sulfur Hexafluoride		SF ₆	.28
Tetrafluoroethylene		F ₂ C:CF ₂	.36
Titanium Tetrachloride		TiCl ₄	.28

<u>CHEMICAL NAME</u>	<u>SYNONYM</u>	<u>FORMULA</u>	<u>F</u>
Freon 116	Hexafluoroethane,	C2F6	.28
	Perfluoroethane		
Genetron 21			.46
Genetron 115	Chloropentafluoroethane	C2ClF5	.27
Germane	Germanomethane	GeH4	.63
Helium		He	1.43
Hydrogen		H2	1.03
Hydrogen Bromide		HBr	.98
Hydrogen Chloride		HCl	.99
Hydrogen Cyanide	Formonitrile	HCN	.79
Hydorgen Fluoride		HF	1.00
Hydorgen Iodide		HI	.94
Hydrogen Selenide	Selenium Hydride	H2Se	.81
Hydrogen Sulfide		H2S	.82
Isobutane	2-Methylpropane,	CH(CH3)3	.30
	Trimethylmethane		
Isobutylene	Isobutene,	(CH3)2C:CH2	.32
	2-Methylpropene		
Krypton		Kr	1.39
Methane	Methylhydride	CH4	.69
Methanol		CH3OH	.58
Methyl Acetylene	Allylene, Propyne	C3H4	.49
Methylamine	Aminomethane,	CH3NH2	.56
	Monomethylamine		
Methyl Bromide	Bromomethane	CH3Br	.64
Methyl Chloride	Chloromethane	CH3Cl	.68

<u>CHEMICAL NAME</u>	<u>SYNONYM</u>	<u>FORMULA</u>	<u>F</u>
Trichlorosilane		SiHCl ₃	.39
Trimethylamine		(CH ₃) ₃ N	.30
Tungsten Hexafluoride		WF ₆	.23
Uranium Hexafluoride		UF ₆	.24
Vinyl Bromide	Bromoethene	C ₂ H ₃ Br	.51
Vinyl Chloride	Chloroethene	C ₂ H ₃ Cl	.54
Vinyl Fluoride	Fluoroethene	C ₂ H ₃ F	.62
Water Vapor		H ₂ O	.79
Xenon		Xe	1.37

SECTION V

MAINTENANCE

5.1 Routine Maintenance:

Under normal operating conditions, no routine maintenance is required. Normal operating conditions are defined here as operating in a clean environment with clean, benign gases, such as filtered air, N₂, O₂, Argon, etc..

When operating in a dirty environment, it is advisable to check for dirt and dust that may have entered the circuit board cover. Remove the cover by loosening the two screws and slipping the cover upward. Inspect for dirt and dust and gently clean the circuit board with a low-pressure air stream or dusting aerosol can. The frequency of these inspections depends on the severity of the operating conditions, and should be established by the user based on experience with the particular application.

When the 825 is used for a gas whose cleanliness is not controlled or specified at its source, then routine maintenance should focus on any filters which may be upstream of the 825. In the absence of such filters, the 825 inlet filter may be cleaned from time to time. The frequency of these cleanings should be established by the user based on system experience, and depends on such factors as: (1) the total accumulated gas flow, (2) the cleanliness of the gas, and (3) the amount of filter pressure drop the system can compensate for. For cleaning, the 825 should be removed to a clean area, and the inlet fitting removed. The inlet filter is welded onto the inlet fitting and can be cleaned by reverse flushing with clean gas or immersion in an ultrasonic cleaner. Remove the fitting o-ring if a cleaning bath is used.

When extremely corrosive gases flow through the 825, routine maintenance of the following components may be required: (1) flow sensor, (2) bypass, and (3) orifice. The flow sensor should be replaced with a new one when internal corrosion of the sensor tube has occurred. The bypass and orifice may be either cleaned or replaced with new components. Replacement and cleaning procedures are explained in Section 5.2. Again, the frequency of this maintenance should be established for the particular application. In some applications, where the moisture content of the gas is not controlled or specified, the corrosion rate may seem unpredictable. This is due to the strong dependence of corrosion rate on moisture content for some gas/metal combinations.

5.2 Special Maintenance:

This section describes special procedure for disassembly, replacement or components, cleaning, and re-ranging the 825. These procedures are usually necessary in response to a degradation in performance encountered under severe service conditions. Re-ranging the 825 is necessary to changing the application to a different gas or flow range.

Recalibration techniques are covered in Section 5.3. Some symptoms of degraded performance are listed below, along with the recommended procedure.

Symptom	Recommended Procedure
loss of sensitivity	replace flow sensor sub-assembly
excess sensitivity	clean or replace bypass
high pressure drop	clean inlet filter (Section 5.1)
valve does not close tight	clean orifice

The procedures for changing the flow sensor, cleaning the bypass, changing the range, cleaning the orifice, and adjusting the orifice are described in the following subsections. These procedures assume that the 825 has been removed from the gas line and taken to a clean area for maintenance. The open ends of the gas line should be sealed immediately to prevent entry of particulate contaminants and atmospheric moisture. The outlet end of the 825 should be sealed (adhesive tape will do) during its transport to the clean area; the inlet is effectively protected by the inlet filter. The clean area should be equipped with laminar flow hoods, degreasing equipment, and necessary tools for disassembly and reassembly of the 825. If maintenance is to include recalibration, then gas flow control and measurement equipment should also be set up in the clean area.

5.2.1 Flow sensor replacement

To remove the flow sensor, first remove the cover by loosening the two clamping screws. Next, loosen the screws holding the circuit board to its bracket; this will permit the circuit board to tilt back and provide clearance for removal of the sensor. Disconnect the three sensor wires from the circuit board.

Remove the two nuts clamping the sensor onto the studs (do not attempt to remove the studs), and lift the sensor straight up over the studs. If the replacement sensor is not immediately available, temporarily seal and protect the openings in the housing with squares of Scotch tape. Be careful not to scratch the area around these openings--these are a seal surface for the flow sensor seal.

Reverse the procedure described above when installing the new flow sensor. Be careful to connect the sensor wires properly. The upstream wire of the sensor goes to the point labeled "C" on the circuit board; the downstream wire goes to "A" and the center wire goes to "B". Dress these wires so they do not interfere with the installation of the cover.

After warming up the 825, adjust the zero flow output with potentiometer R17, as described in Section 2.2 and adjust the bridge voltage as described in Section 5.3. At this point, the 825 will be within a few percent of its original calibration and may be placed in service if this accuracy is acceptable. Alternatively, the unit may be flow recalibrated as described in Section 5.3, or it may be gain adjusted as described below.

To measure the output state gain, offset the zero with R17 to simulate a flow reading near full scale. Then measure the voltages at the output (pin 3) and at the linearizer test point (pin E). The ratio of these voltages, V output divided by V linearizer, is the gain. The gain can be adjusted with potentiometer R26.

If both the old and new flow sensors have flow factors marked on them, the desired gain (new gain) for the output stage can be calculated from:

$$\text{new gain} = \text{old gain} \times \frac{(\text{f of new flow sensor})}{(\text{f of old flow sensor})}$$

where f is the flow factor number marked on the flow sensor. Measure the original gain (described below) before making any adjustments. The original gain may be measured with either the old or the new flow sensor, but in either case, the 825 should be carefully zero-adjusted. In order to avoid the accumulation of error on future sensor replacements, it is advisable to record the original gain and sensor flow factor.

5.2.2 Cleaning the bypass

Cleaning the bypass involves removing the bypass assembly from the 825 (via the inlet fitting), disassembling the bypass, cleaning the bypass discs, reassembling the bypass, and installing it in the 825 housing.

Put the 825 in a vise with soft-faced jaws and place it low in the jaws with the inlet fitting up so that the section nearest the inlet fitting is clamped. Remove the inlet fitting with a 7/8" wrench; up to 80 fts.-lbs. of torque may be required. With a large screwdriver loosen, but do not remove, the thrust plug (which is in the same bore as the inlet fitting). The screwdriver should be wiped clean for this procedure to protect the 825 from being contaminated by falling particles. Remove the 825 from the vise and take it to a laminar flow hood for further disassembly.

Unscrew the thrust plug and tilt the 825 to remove the bypass assembly supporting it on the tip of the finger. The bypass assembly is shown in drawing (C)004867-00 (2 sheets), which is included in this manual. Slide the top end cap (the one with the conical depression) up and off the pins. Slide the bypass discs off the pins individually or in small groups. Note the sequence and orientation of these discs as they are removed; particularly note the orientation of the one, two, three, or four channel flow sets. Leave the pins in the bottom end cap (the one with the central through-hole). In handling these parts, be careful not to bend any of the discs or the pins. They may be cleaned in any solution which does not etch or plate 316 stainless steel.

Assemble by reversing the above procedure. Install the bypass discs one at a time and be careful not to bend them. Be sure to use a cover disc (no slots) between each pair of flow discs. Be careful not to cross-thread the thrust plug; check to be sure its top surface is parallel with the end face of the housing as it is screwed in. Tighten the thrust plug firmly with a large screwdriver; do not use a socket wrench since the added torque may distort the upper end cap. Install and tighten the inlet fitting.

| CAUTION |

Bending the pins or discs or scratching any surfaces may result in erratic operation, especially in the low flow range assemblies.

5.2.3 Changing full scale flow range

The Datametrics bypass kit, part number 105676, contains all the bypass parts necessary to assemble any flow range bypass. The instruction sheet from this kit, as well as assembly drawing (C)004867-00 (2 sheets) are included with this manual. The second sheet of this drawing is a table which defines the arrangement of bypass discs for each standard flow range.

The two highest range (10 SL/M and 20 SL/M) mass flow controllers have a physical construction which is different than that for the lower flow ranges (5 SCC/M through 5,000 SCC/M). Range changes may be made within the lower flow range group or within the high flow range group; but range changes from one group to the other, e.g., changing 10 SL/M to 5,000 SCC/M, may cause trouble with linearity and retention of the bypass assembly.

To make a bypass for air, or for another gas with a gas factor near unity, see the table on drawing (C)004867-00 to determine the quantities and types of bypass discs to use. The 10 SL/M and 20 SL/M bypasses use double sets of discs, i.e., two of each type is used in a set (four total), so that each flow channel is double height. Pay particular attention to the relative orientation of the discs required to make four, three, two, and one channel sets. Follow the assembly instructions in Section 5.2.2 or those included with the bypass kit.

For gases whose gas factor is not between 0.9 and 1.1, or for odd full scale ranges, full scale output will not be within the range of adjustment of the gain potentiometer, R17, when one of the standard bypasses is used. For these cases, it will be necessary to either (1) make a resistor change in the output amplifier, or (2) calculate and build up a special bypass assembly. Adjustments of the output amplifier gain will be covered in Section 5.3, Recalibration.

To make a special bypass assembly, first calculate the total number of channels required from the formulae below:

$$NS = (R/F - 4.86) / (3.50)$$

$$ND = (R/F - 4.86) / (19.15)$$

Where NS is the total number of channels in a low range bypass (less than 10,000 SCC/M) and ND is the total number of double channels for a high range bypass (between 10,000 SCC/M and 20,000 SCC/M). R is the full scale range in SCC/M and F is the gas factor from the table. If a gas is not in the table, or if a mixture of gases is being used, see Section 3.2.1 for a method of calculating gas factors.

From NS or ND calculate the number of sets required for each type of bypass disc.

Low range:

$$\text{number of 36-channel sets} = \text{INT} (NS/36) = S36$$

$$\text{number of 4-channel sets} = \text{INT} ((NS - 36 \times S36) / 4) = S4$$

the balance of the channels, NS-36xS36-4xS4, determines whether to use a three, two, or one channel set.

High range:

number of 36-channel sets = INT (ND/36)

Assemble the corresponding bypass according to the instructions in Section 5.2.2 or those included with the bypass kit. Select a pin height equal to or slightly higher than the bypass height. If it is necessary to cut pins to length, be careful not to mar the surface finish on the pin; also remove all burrs or chamfer the cut end.

5.2.4 Changing the valve orifice

The following procedures (removal, installation, and adjustment) are necessary for cleaning the orifice or for replacing the orifice, usually to change the orifice size. See the following section for selection of orifice sizes. Perform these procedures in a clean area or in a laminar flow hood. Remove the outlet fitting as follows: Put the 825 housing in a vise with soft-faced jaws; place it low in the jaws with the outlet fitting up so that the section nearest the outlet fitting is clamped. Remove the fitting with a 7/8" wrench; up to 80 ft.-lbs. of torque may be required. Be careful not to let the armature assembly fall out of the housing assembly. The orifice can be removed from the outlet fitting by inserting a special tool through the tube end of the fitting. This tool can be made by grinding the shank of an ordinary screwdriver so that it fits into the thru-hole of the fitting (.19" minimum). Remove the o-ring, being careful not to tear it or scratch the sealing surface on the orifice.

Prior to installation, determine if the o-ring can be re-used or if a new one is necessary. The o-ring size is 2-011; the material is specified in the 825 model number after the gas (after the fourth dash). Install the o-ring by carefully stretching it over the back end of the orifice. Install the orifice in the outlet fitting by simultaneously pushing it with a finger and turning it with the special screwdriver described above. Be sure that the orifice is screwed down as far as it will go in the outlet fitting, but leave it free enough to adjust later. Prior to installing the fitting in the housing, be sure the armature assembly is in place. Install the fitting and tighten to the original torque.

It is necessary to adjust the orifice after assembly is complete. This is best done under flow conditions by using the special screwdriver inserted through the outlet tube fitting. Connect air or nitrogen to the inlet of the 825 and set the pressure to approximate the conditions of use. Measure the valve voltage between pins D and F during the adjustment. Adjust the set point to control the flow at full scale. Turn the orifice through the outlet end until the valve voltage reaches one of the values in the table below:

<u>Full scale flow range</u>	<u>Valve voltage at full scale flow</u>
5 to 50 SCCM	6.0 volts
100 to 500 SCCM	7.0 volts
1 to 5 SLPM	8.0 volts
10 to 20 SLPM	10 to 12 volts
	(valve voltage is measured from pin D to pin F)

5.2.6 Selecting orifice size

Orifice size must usually be changed concurrently with a large change in flow range or operating pressure. Incorrect orifice size may result in inability to attain full scale flow or unstable flow control. Each orifice is stamped with a code letter identifying the orifice diameter; see the table below.

ORIFICE SIZES

<u>CODE</u>	<u>DIAMETER</u>
A	.100 inch
B	.062
C	.046
D	.032
E	.019
F	.011
G	.006
H	.004
J	.002

Use the table below to select the orifice size for the specified flow range and operating pressure. If the operating condition falls between two of those in the table, use the larger orifice. For the lowest flow ranges it may be convenient to tune the upstream pressure for the most stable operation.

ORIFICE SELECTION

Pu = upstream pressure, absolute, PSIA

Pd = downstream pressure, absolute PSIA

Pu:	115	65	30	20	16	15.5	15
Pd:	15	15	15	15	15	15	0

RANGE

SIZE CODE

20 SL/M	D	*	*	*	*	*	*
10 SL/M	E	D	C	C	*	*	*
5 SL/M	F	E	D	B	B	A	C
2 SL/M	F	F	E	D	C	B	D
1 SL/M	G	F	F	E	D	C	E
500 SCC/M	H	G	F	F	E	D	F
200 SCC/M	H	H	G	G	F	E	F
100 SCC/M	J	H	H	G	F	F	G
50 SCC/M		J	H	H	G	G	H
20 SCC/M			J	H	H	G	H
10 SCC/M				J	H	H	J
5 SCC/M				J	J	H	J

The asterisk indicates pressure/flow regions where the larger orifices tend to close due to the force applied by the differential pressure (SEE SECTION 3.3.2). The largest orifices can be used for special applications, such as controlling low vapor pressure gases at sub-atmospheric pressures.

5.3 Recalibration:

Recalibration of the 825 mass flow controller may be necessary after extensive repair or modification of the sensor, bypass, or circuit board, or if the gain and linearity potentiometer settings are moved by mistake.

A flow calibration system should have the following components:

- a means for establishing and maintaining a steady flow of gas
- a means for measuring gas volumes, such as a mercury sealed piston prover
- a timer

- a thermometer
- a barometer or absolute pressure transducer

The 825 itself may be used to control the calibration flow, or its valve can be commanded to the full open position while flow is controlled by another valve upstream. Mass flow is stated as standard cubic centimeters per minute, SCC/M, which is the equivalent volume flow rate at standard conditions of temperature and pressure. The standard conditions used for the 825 are 70oF and 760 Torr. Mass flow, Q_s , can be calculated from volume flow, Q , with the equation:

$$Q_s = Q \times \frac{P}{(T+459.7)} \times \frac{(70+459.7)}{760}$$

where P is the absolute pressure in Torr and T is the temperature in oF.

To calibrate, first warm up the instrument and perform a zero adjustment as described earlier. Set the bridge current by measuring the voltage across resistor R13 and adjusting potentiometer R4. The proper R13 voltages are: .500 for a standard sensor, .620 for a fast response sensor. Then establish a flow rate near the full-scale range of the instrument. Measure the volume flow rate with the volume prover and timer, as well as the pressure and temperature of the gas entering the prover. Calculate Q_s from the data. Adjust gain potentiometer R26 for agreement between Q_s and the instrument reading.

SECTION VI
SUPPLEMENTARY DATA

6.1 List of Illustrations:

Drawings:

Circuit Board Assembly
Bypass Assembly
Circuit Diagram

Tables:

Table 1	Gas Factors
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Miscellaneous:

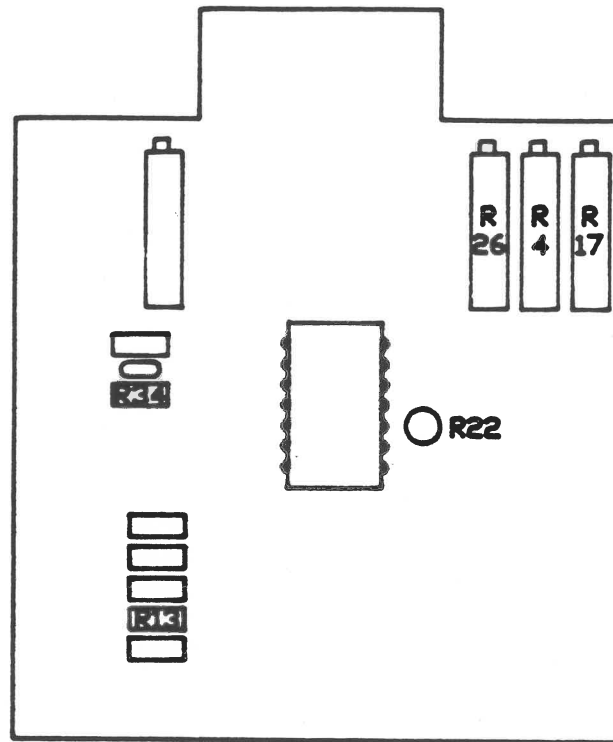
- Photograph of 825 mass flow controller
- Instruction sheet from bypass kit, P/N 105676
- 825 Brochure

6.2 Claim for Damage in Shipment:

Reasonable effort has been taken to pack the Type 825 so that it reaches you in perfect operating condition. The first thing you should do when unpacking the equipment is to look for dents, cracks, or broken components outside or inside the enclosure. If you find any damage, notify the carrier immediately and save all packing material until the claim is settled. Read the carrier's shipping papers carefully for specific provisions and instructions in the event a claim for damage must be made.

6.3 Warranty:

Follows the last page.



ASSEMBLY, P.C. BD. TYPE 825

REVISIONS		
REV	DESCRIPTION	DATE

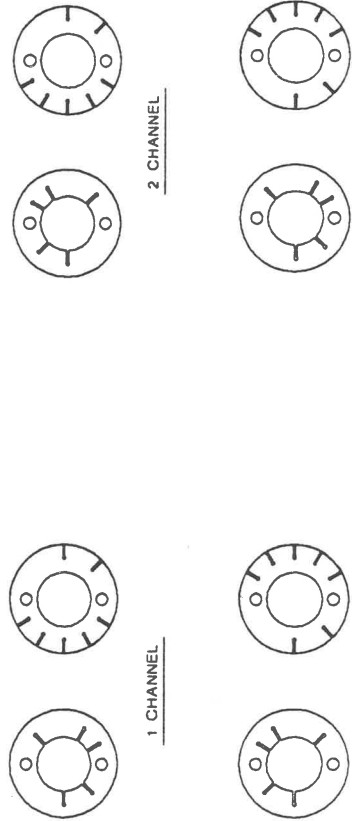
PART NUMBER	FLOW RANGE SCCM	SET COMBINATIONS/QTY				"L"	PIN NUMBER	# CHANNELS	DISC COMPLEMENT			
		36 CHANNEL	4 CHANNEL	3 CHANNEL	2 CHANNEL	1 CHANNEL			(C)304472-00	(C)304473-00	(C)304470-00	(C)304471-00
PI600611-01	5						.189 (A)304864-01	0				(C)304469-00
PI600611-02	10				1		.197 (A)304864-01	2			1	2
PI600611-03	20		1			1	.205 (A)304864-01	5			2	3
PI600611-04	50		3		1		.221 (A)304864-01	14			4	5
PI600611-05	100		7			1	.253 (A)304864-03	29			8	9
PI600611-06	200	1	6				.245 (A)304864-01	60	1		6	8
PI600611-07	500	4	2			1	.245 (A)304864-01	153	4		3	8
PI600611-08	1000	8	4		1		.293 (A)304864-03	306	8		5	14
PI600611-09	2000	17			1		.333 (A)304864-04	614	17		1	19
PI600611-10	5000	42			1		.581 (A)304864-05	1538	42		7	50
PI600611-11	10000	15 DOUBLE 30 SINGLE					.400 (A)304864-04	840 DOUBLE 1680 SINGLE	32		32	18
PI600611-12	20000	42 DOUBLE 84 SINGLE					.611 (A)304864-05	1538 DOUBLE 3064 SINGLE	64		64	35

FOR LOW RANGE LAMINAR FLOW ELEMENTS (FOR RANGES 100 TO 20,000 USE P600611-05 TO P600611-12)

PI600611-13	5					1	.197 (A)304864-01	1			1	1	2
PI600611-14	10						.197 (A)304864-01	3			1	1	2
PI600611-15	20		1			1	.205 (A)304864-01	6			2	2	3
PI600611-16	50		3		1		.221 (A)304864-01	15			4	4	5

FOR LOW VOLUME BY-PASS ASSEMBLY USE (PI600650-01 TO PI600650-03)

PI600650-01	5						.189 (A)304864-01	0					
PI600650-02	10				1		.197 (A)304864-01	1			1	1	2
PI600650-03	20		1			1	.205 (A)304864-01	4			2	2	3

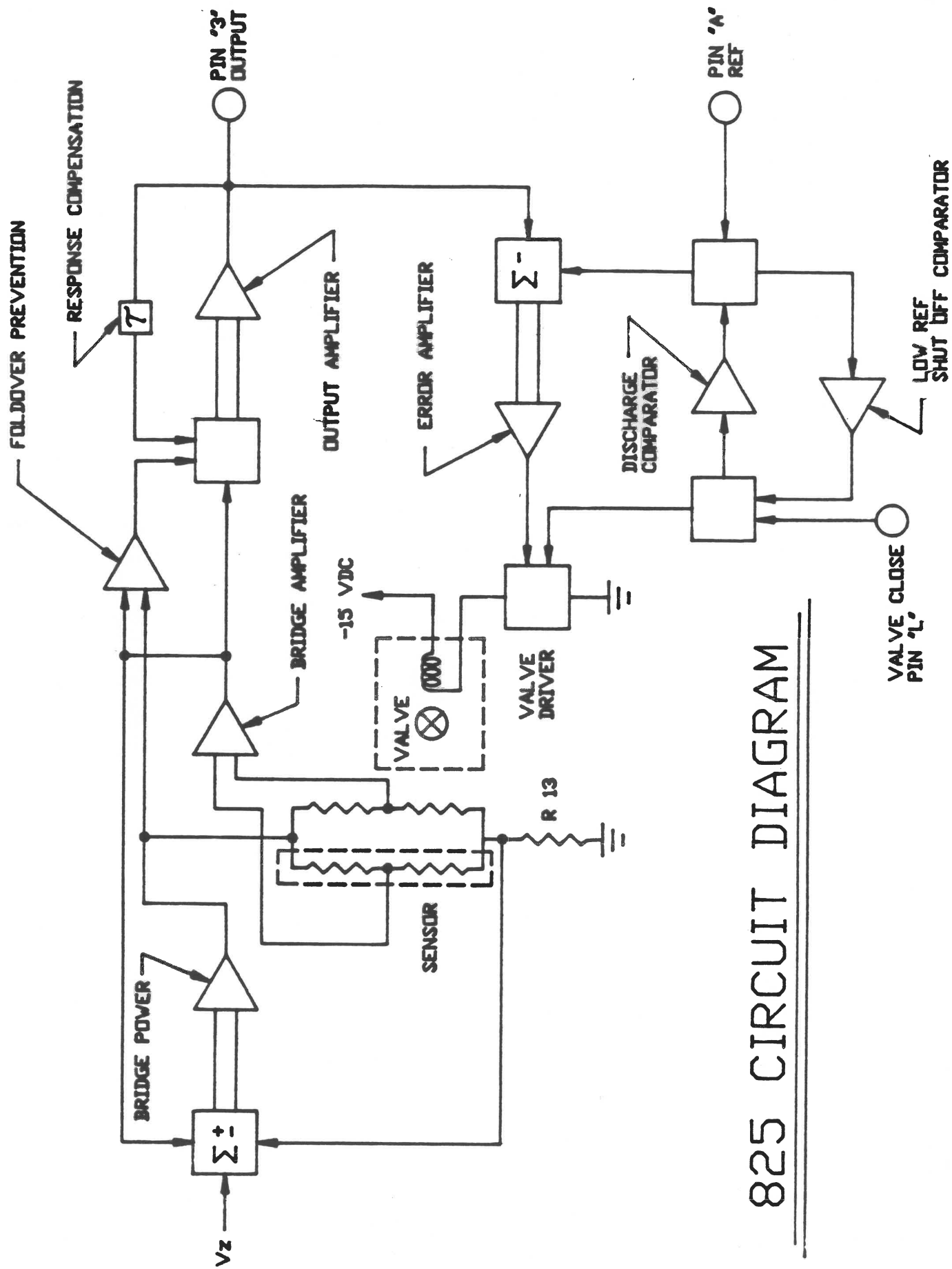


NOTES:

1. DOUBLE SETS: USE COVER DISC, FOLLOWED BY TWO PLENUM CHAMBER DISCS, TWO DELIVERY CHAMBER DISCS, THEN COVER DISC AND NEXT SET.
2. DO NOT DAMAGE THE FINISH ON THE END CAPS WHEN HANDLING AND DURING ASSEMBLY.
3. ASSEMBLE BY-PASSES IN A LAMINAR FLOW HOOD AND BAG THEM INDIVIDUALLY.
4. FOR LOW RANGE LAMINAR FLOW ELEMENTS (FOR RANGES 100 TO 20,000) USE PI600611-05 TO PI600611-12.
5. SCCM FLOW IN STANDARD UNIT TEMPERATURE OF 0°C WITH NITROGEN GAS.
6. OVERALL LENGTH OF BY-PASS MUST BE LESS THAN .780

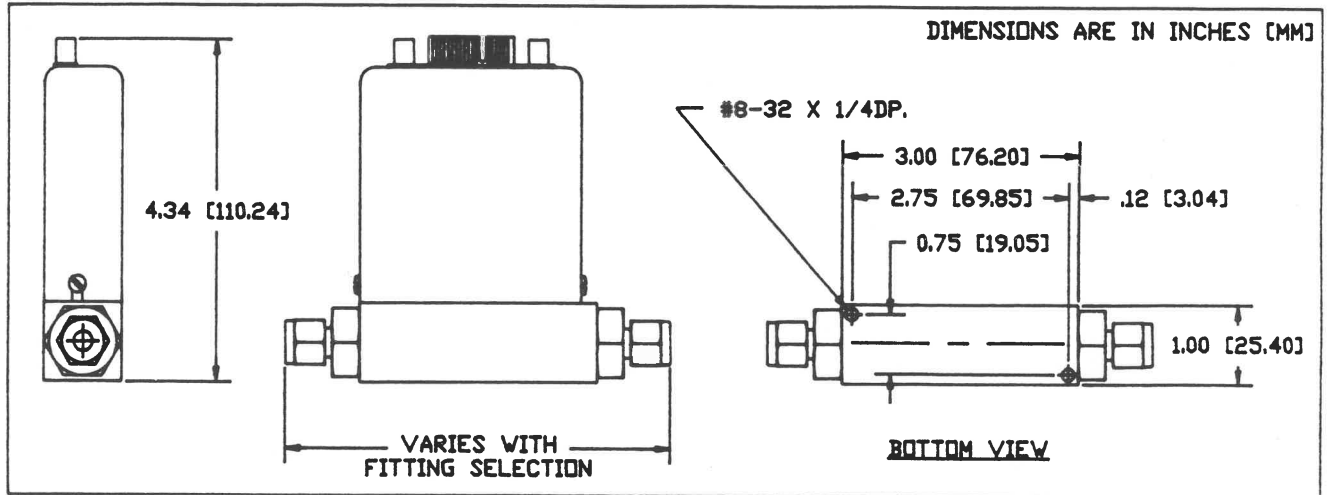
DISC ORIENTATION

DESIGN: A70000 P6500	DATE: 8/7/98	TOURNADES: 10/1/98	REVISION: 1
DESIGNED: [Signature]	APPROVED: [Signature]	DESCR: AS NOTED	REVISION: 1
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.			
DO NOT SCALE DRAWING			
SEE SHEET 1 OF 2			
PARTS:			
ASSEMBLY BY-PASS MASS FLOW CONTROLLER			
DRAWING NO. 000612-00			
REV. A			



825 CIRCUIT DIAGRAM

OUTLINE DIMENSIONS



HEALTH AND SAFETY CLEARANCE FORM

- 1.0 This form must be used when returning equipment for service at Edwards or Edwards distributor.
- 2.0 A completed copy of this form should be faxed or mailed first class to insure that we have this form before we receive the equipment.
- A further copy should be handed to the carrier with the equipment.
- 3.0 Failure to complete the form or comply with the procedure will lead to delays in servicing the equipment.
- 4.0 Please complete the following sections:
- 4.1 Equipment type
- 4.2 Serial No:.....
- 4.3.0 Details of all substances that the equipment has been exposed to:
- 4.3.1 Chemical names:
- (a)
- (b).....
- (c).....
- 4.3.2 Precautions to be taken in handling of these substances:
- (a).....
- (b).....
- (c).....
- 4.4 Any further information which you consider to be relevant:
- 4.5 Please complete section 4.5.1 if substances are not toxic or hazardous; 4.5.2 if they are.
- 4.5.1 I hereby confirm that the equipment specified above has not come in contact with any toxic or hazardous substances.
- Signed:.....
- Name:.....
- Position:.....
- Company:.....
- Date:.....
- 4.5.2 I hereby confirm that the only toxic or hazardous substances that the equipment specified above has been in contact with are named above, that the information is correct, and that the following actions have been taken:
- 1) The equipment has been thoroughly purged.
- 2) The inlet/outlet ports have been sealed and the equipment has been securely packed and labelled.
- 3) The carrier has been informed of the hazardous nature of the shipment.
- Signed:.....
- Name:.....
- Position:.....
- Company:.....
- Date:.....
- 4.6 Carrier to be used:.....
- Delivery date to Edwards:.....

Mass Flow Controller/Transducer (MFC/MFT) Return Instructions

Complete the Health and Safety Clearance (Disclosure) form and describe history of the instrument's exposure to hazardous (toxic or carcinogenic) chemicals. An MFC/MFT which has been exposed to hazardous gases must be purged as follows:

- A) Before removal from the user's installation or system, purge with dry nitrogen at no less than 20 psia for at least 3 minutes. MFC valve must be open.
- B) Pump to vacuum, if available, for at least 5 minutes.
Note: Multiple repeats of steps A & B are recommended.
- C) Remove the MFC/MFT from the installation or system.
- D) The equipment engineer or technician must attach a RED tag to the MFC/MFT indicating the gas used and certify on the disclosure form that the MFC/MFT has been purged properly.

Package all returned instruments per government regulations including the following:

- 1) Place the MFC/MFT in a plastic protective bag and seal.
- 2) Place in a shipping container with adequate packing.
- 3) Ship to Edwards via reliable service, under any applicable Department of Transportation Guidelines.

Edwards personnel will handle returned units per Dwg. No. 000802-00.

Return Information

If you wish to return a unit to Edwards, following these general procedures will ensure optimal service-return:

1. Call 1-800-848-9800 for a return authorization number.
2. Read and fill out the Health and Safety Clearance Form in this section. It's suggested that you make a copy of the blank form to keep for future use.
3. If a sensor is to be returned, follow the Transducer Return Instructions in this section.
4. Cover any ports to keep packing material out of the unit.
5. Pack the unit carefully with plenty of shock absorbing material. Preferably use the original packing carton.
6. Enclose a description of the symptoms in as much detail as possible.
7. The package can be sent via Parcel Post, Air Freight, or any normal transportation, according to your requirements. Boat shipments should have normal salt spray protection. Return to factory must be prepaid, as we cannot accept collect shipments.

HEALTH AND SAFETY CLEARANCE FORM

DWG NO. 901173-00

- 1.0 This form must be used when returning equipment for service at Edwards or an Edwards distributor.
2.0 A completed copy of this form should be faxed or mailed first class to ensure that we have this form before the equipment is received.
A further copy should be handed to the carrier along with the equipment.
3.0 Failure to complete this form and/or comply with procedure will lead to delay in the service of the equipment.

4.0 Please complete the following section:

4.1 Equipment type:

4.2 Serial No:.....

4.3.0 Details of all substances that the equipment has been exposed to:

4.3.1 Chemical Names:

(a).....

(b).....

(c).....

4.3.2 Precautions to be taken in the handling of these substances:

(a).....

(b).....

(c).....

4.4 Any further information which you consider to be relevant:

.....
.....

4.5 If the above substances are toxic or hazardous, complete section 4.5.2;

If they are not, complete section 4.5.1.

4.5.1 I hereby confirm that the equipment specified above has not come in contact with any toxic or hazardous substances.

Signed:

Name:

Position:

Company:

Date:.....

4.5.2 I hereby confirm that the only toxic or hazardous substances that the equipment specified above has been in contact with are listed above, that the information is correct, and that the following actions have been taken:

*1) The equipment has been thoroughly purged per Edwards procedure (DWG No. 000803-00 or 000851-00).

*2) The inlet/outlet ports have been sealed and the equipment has been securely packed and labelled in accordance with Edwards procedure (DWG No. 000803-00 or 000851-00).

*3) The carrier has been informed of the hazardous nature of the equipment.

Signed:

Name:

Position:

Company:

Date:.....

4.6 Carrier to be used:.....

Delivery date to Edwards:.....

Barocel® Pressure / Vacuum Transducer Return Instructions

DWG NO. 000851-00

Complete the Health and Safety Clearance Form and describe the history of the instrument's exposure to hazardous chemicals.

A Barocel® Transducer which has been exposed to hazardous gases must be purged as follows:

- A) Before removal from the user's installation or system, purge with dry nitrogen at no less than 20 psia for at least 5 minutes.
- B) Pump to vacuum, if available, for at least 5 minutes.

NOTE: Multiple repeats of steps A & B are recommended.

- C) Remove the Barocel® Transducer from the installation or system.
 - D) The equipment engineer or technician must attach a RED tag to the Barocel® Transducer indicating the gas used and certify on the disclosure form that the Barocel® Transducer has been purged properly.
-

Package all returned equipment per government regulations, including the following:

- A) Place the Barocel® Transducer in a plastic protective bag and seal.
 - B) Place in a shipping container with adequate packing.
 - C) Ship to Edwards via reliable service, in accordance with any applicable Department of Transportation Guidelines.
-

Edwards personnel will handle returned units per DWG. No. 000784-00.

Mass Flow Controller/Transducer (MFC/MFT) Return Instructions

DWG NO. 000803-00

Complete the Health and Safety Clearance (Disclosure) form and describe history of the instrument's exposure to hazardous chemicals.

An MFC/MFT which has been exposed to hazardous gases must be purged as follows:

A) Before removal from the user's installation or system, purge with dry nitrogen at no less than 20 psia for at least 5 minutes. MFC valve must be open.

B) Pump to vacuum, if available, for at least 5 minutes.

Note: Multiple repeats of steps A & B are recommended.

C) Remove the MFC/MFT from the installation or system.

D) The equipment engineer or technician must attach a RED tag to the MFC/MFT indicating the gas used and certify on the disclosure form that the MFC/MFT has been purged properly.

Package all returned instruments per government regulations including the following:

1) Place the MFC/MFT in a plastic protective bag and seal.

2) Place in a shipping container with adequate packing.

3) Ship to Edwards via reliable service, under any applicable Department of Transportation Guidelines.

Edwards personnel will handle returned units per Dwg. No. 000802-00.

WARRANTY

EDWARDS HIGH VACUUM INTERNATIONAL, a division of the BOC Group, Inc., warrants products of its own design and manufacture to be free from defects in material and workmanship when used under normal conditions and service and have not been subjected to physical damage or abuse.

EDWARDS will either repair or replace at their option any instrument found to be defective upon its return within one year from the original date of shipment. Transportation charges must be prepaid. This warranty carries no liability, either expressed or implied, beyond the obligations outlined above.

This warranty is void if this product is subjected to misuse, accident, neglect or improper application, installation, or operation.